

Discovery of a Hunan population of *Luehdorfia chinensis* (Lepidoptera: Papilionidae) in China with preliminary notes on its conservation

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Abstract The swallowtail butterfly *Luehdorfia chinensis* (Leech, 1893) is endangered in China. Although its biological characteristics and habitat were reported more than twenty years ago, its conservation biology remained insufficiently known. In 2009, we discovered a population of the butterfly in Wuyunjie National Nature Reserve, Hunan, and preliminary data on the biology of this population was accumulated from March 2009 to July 2010, based on laboratory rearing and surveys in the field. Its life history was similar to those of the Zhejiang and Suzhou populations, and its habitat was on a slope around the mountaintop with its main host plant *Asarum sieboldii*. In Wuyunjie National Nature Reserve, human activities, such as cultivating and mowing are permitted to local residents to support the relationship between people and nature. Ruderal environments with sunlight and open spaces produced by moderate burning and mowing in the habitat may play important roles in maintenance of the population. Because suitable habitat of *L. chinensis* requires a comparatively open environment, logging high trees in the lowland may be necessary to sustain the Hunan population.

Key words *Luehdorfia chinensis*, conservation, Hunan, China.

Introduction

Luehdorfia chinensis (Leech, 1893), a Chinese endemic species found only in the lower-middle Yangtze River valley and the Qinling area (Hu, 1982), is recognized as a globally rare and endangered butterfly, with the primary host plants being *Asarum forbesii* and *A. sieboldii* (Aristolochiaceae). Regarded as a national second-class protected animal in China (State Council of the PRC, 1989), it is also ranked as Data Deficient (DD) in the global Red List of Threatened Animals (IUCN, 2010), and has been recorded in that list since 1985 (Collins, 1985; IUCN, 1990; Groombridge, 1994; Baillie and Groombridge, 1996). Yuan *et al.* (1998) considered that the populations of *L. chinensis* were characterized into two types: (1) the higher mountain type distributed only in the Qinling Mountains of central China from 1000 m to 2000 m with the habitat of a deciduous broad-leaved forest and *A. sieboldii* as the main host plant, and (2) the lowland type distributed in the lower-middle reaches of the Yangtze River under 200 m with the habitats of mostly secondary forests and *A. forbesii* as the main host plant. Although the biological characteristics and habitat of *L. chinensis* were studied by some authors (Tong and Qian, 1982; Hu, 1982; Yuan *et al.*, 1998), the Hunan population was not treated in previously studies.

In order to gain information on the butterfly population and provide the conservation rationale for the Hunan population, laboratory rearing and preliminary field surveys

were conducted in Wuyunjie National Nature Reserve, China. Based on these data, initial recommendations were developed for the conservation of *L. chinensis* in Hunan.

Materials and method

Area and sites.

The investigation was conducted in Wuyunjie National Nature Reserve (28°30'–28°39'N, 111°07'–111°29'E) with an area about 338 km² and 92.5 % forest cover, which is located in Taoyuan County, Changde City and near to Anhua County, Yiyang City, Hunan province (Fig. 1).

Butterfly population and patch dynamics

We discovered *L. chinensis* on a mountain slope in Wuyunjie National Nature Reserve on 18 March, 2009. Then, we mapped 4 transect routes along which to survey the *L. chinensis* population: ①. ④. Xixi-Xiaoxi-Zhujiachong (see Fig. 1–III). The distribution of *L. chinensis* was surveyed in the reserve by walking along the routes with 2–3 field workers during the adult peak flight period in March and April, in 2009 and 2010. Survey methods included observing the butterflies and searching for eggs or larvae on the host plants (*A. forbesii* and *A. sieboldii*) on both sides of the routes, as well as recording the latitude and longitude of each observation point using GPS, the presence or absence of its host plants at the points.

Life history characteristics

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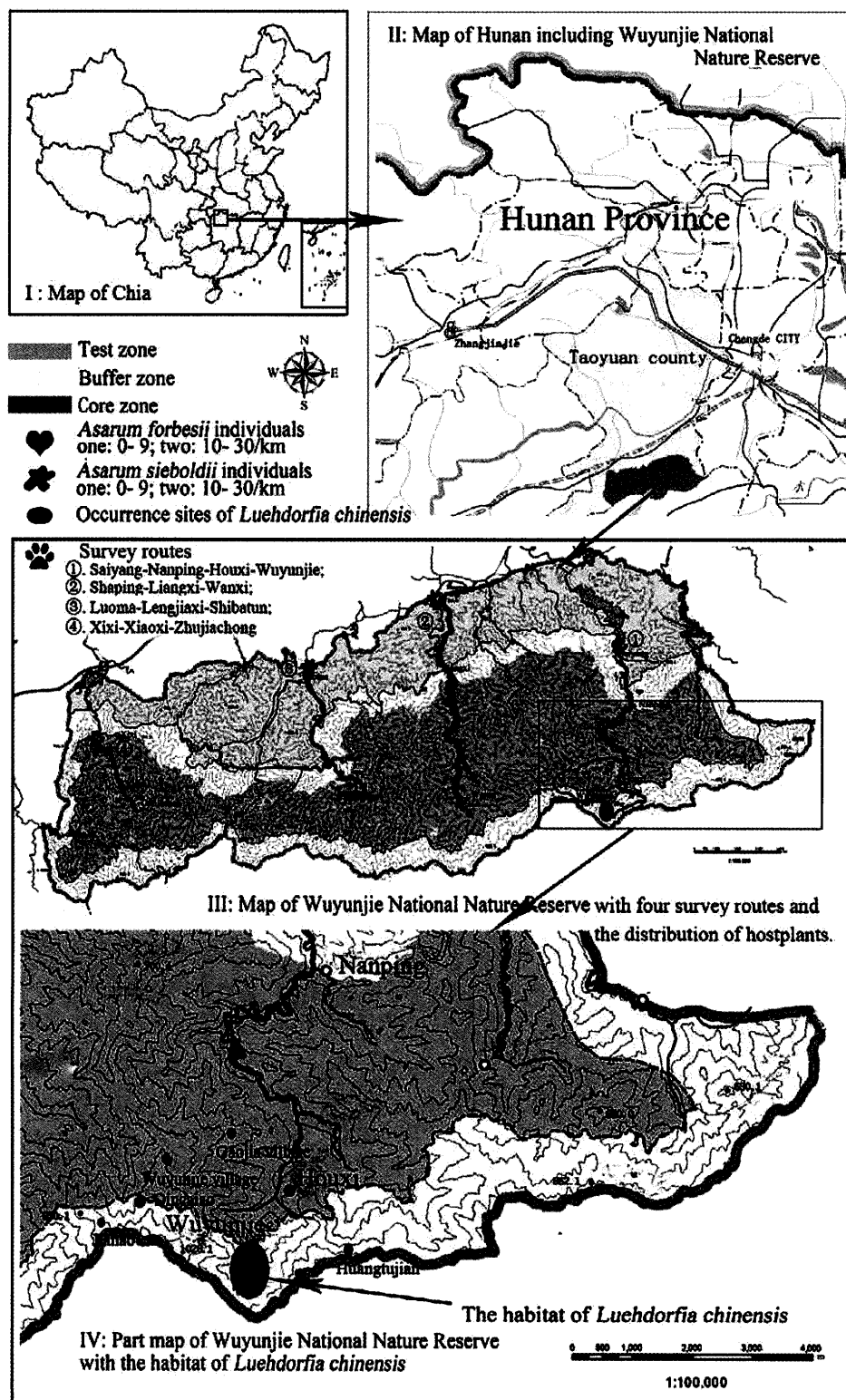


Fig. 1. Map of investigation site with the habitat of *Luehdorfia chinensis* in Hunan Province, China.

Eleven eggs of *L. chinensis* were obtained from Wuyunjie National Nature Reserve in 2009, and reared in the laboratory. Larvae were fed with fresh leaves of *A. sieboldii*. The duration of egg stage, different larval instars and the time of pupation were assessed by observing them four

times a day. Field observation was conducted quarterly and over 10–14 days at a time from March to July in 2009 and 2010.

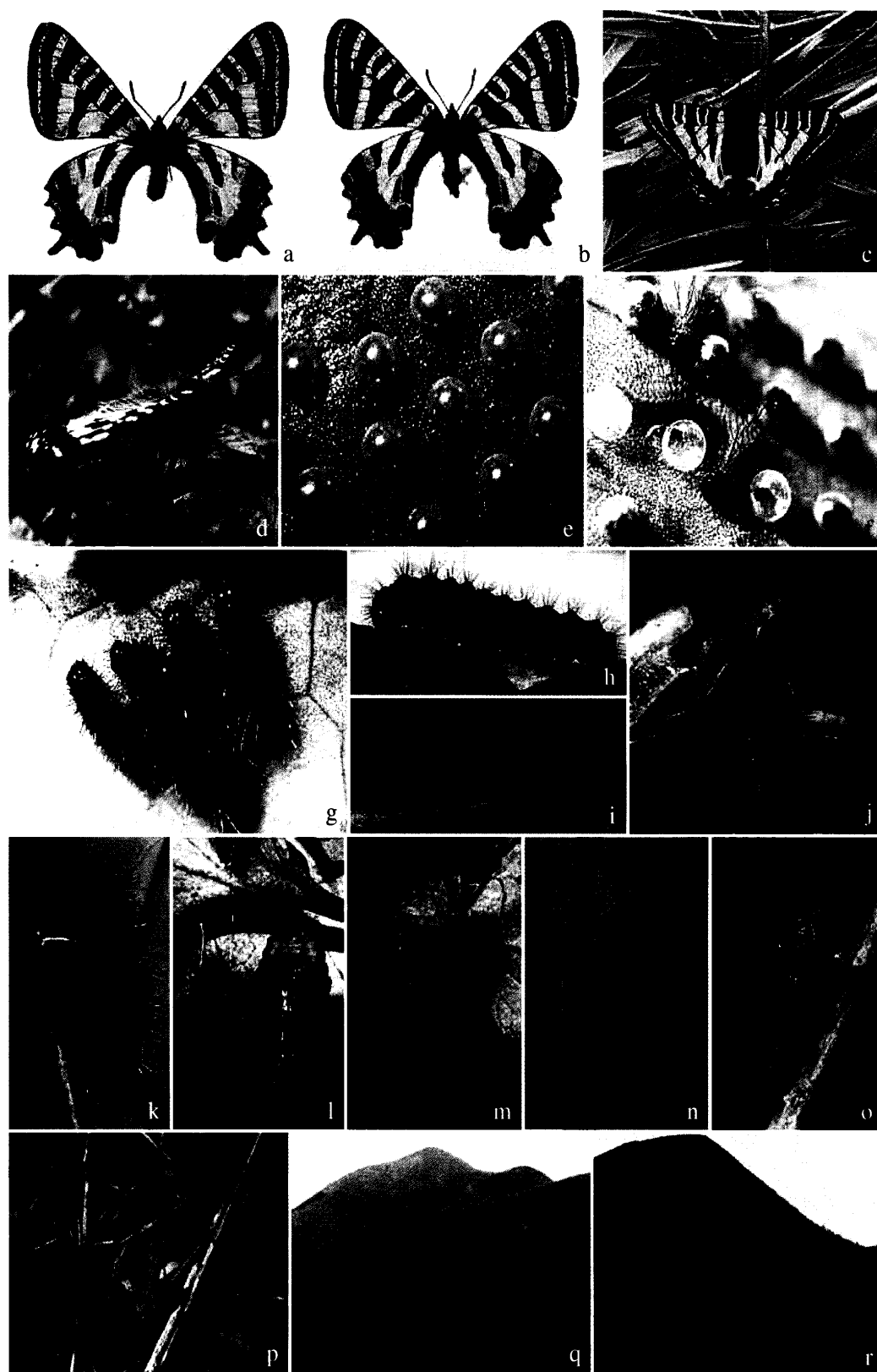


Fig. 2. Immature stages and the habitat of *Luehdorfia chinensis* (Leech, 1893). (a). Male adult; (b). Female adult; (c-d). An adult perching on a plant; (e). eggs; (f). First instar larva; (g). Second instar larva; (h). Third instar larva; (i). The last instar larva; (j). Fourth instar larva; (k). Pre-pupating larvae; (l-o). Pupae including prepupa, imago chrysalis and pupa; (p). Host plant (*Asarum sieboldii*); (q-r). Habitat.

Distribution of hostplants

In order to characterise the suitable habitats for the butterfly, the distribution of its host plants was surveyed as above and counting the number of host plant per kilometer (N/km) in different seasons from March 2009 to July 2010. The surroundings of each collected adult were recorded with vegetation type, and presence of larval host plants.

Results

Life history

The adults emerged from mid to late March and peaked in late March, and the flight period ended towards mid-April. Eggs are laid from late March onward. The eggs (light green, ellipsoidal, with a diameter of 0.978 mm in length, 0.754 mm in height, see Fig. 2e) began to hatch in late April. As embryonic growth progresses, the egg become transparent and the ten first instar larvae emerged (Fig. 2f). The egg period was 20.0 ± 2.50 days (Table 1). The total duration of the five larval instars (Fig 2. f-j) was 30-35 days from late April to early June. The larvae were fully grown by mid June. The pre-pupae period was about 2 days and the entire pupal stage could not be recorded due to their death from unknown causes (Fig. 2. k-o).

Table 1. The egg, larva, and pre-pupal periods (days) of *Luehdorfia chinensis* from Wuyunjie National Nature Reserve fed with *A. sieboldii*.

Stage	Sample number	Mean \pm SD(d)	Range(d)
Egg	11	20.0 \pm 2.50	18.0-24.0
First instar	10	6.85 \pm 0.14	4.50-8.00
Second instar	10	6.05 \pm 0.21	4.20-6.50
Third instar	9	4.95 \pm 0.11	4.50-6.50
Fourth instar	9	5.85 \pm 0.17	4.35-6.80
Fifth instar	8	9.60 \pm 0.22	8.00-10.0
Pre-pupae	8	2.00 \pm 0.25	1.50-2.70
Pupa	8	-	-

Adult behavior

Adults were most active in the afternoon. During the search for mates, they flew just near the ground along the slope. Males flew strongly high above the ground, moving far from the emergence sites. Mating behavior generally occurred around noon. The male often flapped the wings when encountering a mate, then bent the abdomen toward the female. If the mating was successful, it continued for 23.5 minutes in average before separation.

Population quantity

Many adults, eggs and larvae of *L. chinensis* were observed at Wuyunjie National Nature Reserve. All eggs and larvae (a total of 315 individuals) were only found on the moun-

tain slope. Also, most adults were observed on the slope around the mountaintop (Table. 2). At that site, a much larger number of butterflies, about 50 individuals were observed flying or perching on foliage on March 19, 2009 (Fig. 2c-d). This was the adult peak flight period, after which because of a long period of rain, natural enemy and population dispersal, the butterfly numbers seemingly began to seen decreased gradually.

We also recorded adults from Gaojia village, Wuyunjie village, Huangtujian, Jianao and Qincaiao, but there were no hostplants in these sites except Gaojia village (Table. 2).

Habitat requirements

Host plants were found easily on both sides of the survey routes, with *A. forbesii* more abundant than *A. sieboldii* (Fig. 1-III). This may have been fortuitous, reflecting the position of routes, largely at lower elevations. Although the two plants often grow together, they also occur at different elevations. *A. forbesii* mainly grows along forested paths and in the shade of the grove of forest edges, distributed over elevations ranging from 400 to 800 m asl. *A. sieboldii* are generally distributed around the hill-tops at the altitude from 800 m to 1000 m in the ruderal environments. Occasionally, they were found at the foot of the mountain. The eggs and larvae were found only on *A. sieboldii* which is distributed only on the mountain slope from 980 m to 1000 m (Table. 2).

The mountain is located in the buffer zone of Wuyunjie National Nature Reserve, 1 km from Anhua county and 22 km from the town of Shaping (Fig. 1-IV). The elevation ranges from 900 to 1000 m asl. The habitat is a tract of meadow with an area of approximately 800 m², and is similar to higher mountain type (Yuan *et al.*, 1998) with no trees except some brushwood which covers about 10% of the site. Many kinds of weeds were the main plants in the habitat, which covered nearly the whole habitat with an area about 600 m². The coverage of *A. sieboldii* was about 10-15%. In spring and winter, vegetation turned to dry grass, increasing exposure of other plants to the sunshine, and reducing the level of shading to nearly zero. At the start of summer, grass and bush began to grow, and the habitat was covered by thick weeds. The top of the hill suffers only very light human activity. But in order to collect an economic plant (a kind of edible fern that appears early spring), local residents burn dry grass beside the habitat in winter, which had just taken place in 2009. Around the habitat, there are mountains, also covered by weed and some firebreaks, such as *Magnolia officinalis* Rehd. Et Wils.

Table. 2 Occurrences of geographical data, habitat type and host plants of *Luehdorfia chinensis* observed in Wuyunjie National Nature Reserve, Hunan.

Adults	Date	Site	Latitude and Longitude	Elevation	Habitat type	Host plants
1 ♀	2009/3/18	Gaojia village	28° 33'59"N, 111° 22'25"E	637 m	broad-leaved	<i>A. forbesii</i>
2 ♀	2009/3/18	Wuyunjie village	28° 33'31"N, 111° 21'58"E	805 m	bamboo forest	Absent
1 ♂	2009/3/19	Mountaintop	28° 33'22"N, 111° 22'28"E	949 m	grassland	<i>A. sieboldii</i>
1 ♂	2009/3/19	Mountaintop	28° 33'21"N, 111° 22'28"E	950 m	grassland	<i>A. sieboldii</i>
1 ♂ 2 ♀	2009/3/19	Mountaintop	28° 33'19"N, 111° 22'27"E	969 m	grassland	<i>A. sieboldii</i>
1 ♂	2009/3/19	Mountaintop	28° 33'18"N, 111° 22'26"E	986 m	grassland	<i>A. sieboldii</i>
1 ♂	2009/3/19	Mountaintop	28° 33'15"N, 111° 22'26"E	988 m	grassland	<i>A. sieboldii</i>
1 ♂	2009/3/19	Mountaintop	28° 33'18"N, 111° 22'27"E	989 m	grassland	<i>A. sieboldii</i>
1 ♂ 2 ♀	2009/3/19	Mountaintop	28° 33'22"N, 111° 22'28"E	929 m	grassland	<i>A. sieboldii</i>
1 ♂	2009/3/19	Mountaintop	28° 33'22"N, 111° 22'27"E	929 m	grassland	<i>A. sieboldii</i>
1 ♀	2009/3/20	Huangtujian	28° 32'33"N, 111° 21'58"E	671 m	grassland	Absent
1 ♀	2010/3/24	Jianao	28° 33'01"N, 111° 21'45"E	780 m	grassland	Absent
2 ♂ 1 ♀	2010/3/26	Mountaintop	28° 33'23"N, 111° 22'28"E	938 m	grassland	<i>A. sieboldii</i>
1 ♂ 1 ♀	2010/3/26	Mountaintop	28° 33'20"N, 111° 22'28"E	957 m	grassland	<i>A. sieboldii</i>
1 ♂	2010/3/26	Mountaintop	28° 33'19"N, 111° 22'27"E	976 m	grassland	<i>A. sieboldii</i>
1 ♀	2010/3/26	Qincaiao	28° 33'31"N, 111° 21'58"E	975 m	grassland	Absent

Discussion

Yuan *et al.* (1998) reported that the population structure of *L. chinensis* is a typical metapopulation. According to our investigation, the population in Wuyunjie National Nature Reserve is mainly distributed around the top of Wuyunjie Mountain, and life history pattern of the population is similar to those in Zhejiang and Suzhou, but the duration of larval instars is longer than in these other two populations. According to Yuan *et al.* (1998), secondary deciduous forest is the preferred habitat for *L. chinensis*, and the population of the lower–middle reaches of Yangtze River belongs to lowland type. Although the north of Hunan Province is located in the middle reaches of Yangtze River, the population found in the present survey is more similar to the higher mountain type, while the habitat is grassland, not the deciduous broad-leaved forest.

The occurrence of the different habitat types in the same area may be relevant to reflect the arbitrary measure of protection in the national reserve. In Wuyunjie National Nature Reserve, a series of human activities, such as cultivating and mowing are permitted to local residents to promote a harmonious relationship between people and nature, but cutting down bamboos and firewood are prohibited. The host plants are widely distributed in the whole area, but mostly covered by forest. *L. chinensis* requires suitable sunlight and space to complete the process of reproduction and mating. Consequently, the butterfly population was restricted to mountaintop habitats.

The host plant *A. forbesii* occurs in Gaojia village, which is covered by broad-leaved forest with about 80% canopy cover, and the host plant mainly grows in the shade of the

grove. However, eggs and larvae were not found in the site. Therefore, by comparing the two different sites, we concluded that the requirements of suitable habitat for the butterfly must include an open air and host plants.

Generally, human effects such as over-exploitation and habitat degradation cause butterfly decline (New, 1991). Indeed, human activities such as destruction of forest for reclamation, grazing and cutting firewood can result in loss and fragmentation of habitats. On the other hand, some human activity may give positive effects for the conservation of *L. chinensis*. Moderate disturbance by fire was noted as an essential factor in perpetuating long-term stability and species diversity across landscapes (MacCullough *et al.*, 1998). Ruderal environment with sunlight and open spaces produced by moderate burning or mowing in the habitat may play important roles in maintenance of the population. In order to conserve the population in Hunan, we should not only manage the current habitat in the Wuyunjie Mountaintop, but also create advantageous condition to help the population to extend its range, for example by logging trees in the lowland.

Because the population was discovered in the reserve for the first time in March 2009, it is hard to indicate the state of endangerment of the population in the reserve at present, and further investigation is needed. However, the results obtained from our preliminary surveys suggest that the population may be faced with danger, for example, from shortage of hostplant because of it being collected by local residents as a medicinal plant and loss of open habitat owing to overgrowth of shrubs and trees. Therefore, further attention should be paid to the Hunan population,

and careful management is needed to integrate human needs with propagation of the butterfly in the future.

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摘 要

中国湖南省におけるシナギフチョウの発見と保全に関する知見 (李 密・周紅春・譚濟才・劉国華・黄国華)

中国特産種シナギフチョウ *Luehdorfia chinensis* (Leech, 1893) は、中国の「国の重点保護野生動物リスト」では二級保護動物、IUCN (国際自然保護連合) レッドリストではDD (情報不足種) に指定されている。シナギフチョウ (以下、本種) は中国の長江流域および秦嶺山脈に広く分布していたが、最近、中国の地域経済の活性化にともなって、生息地が減少・分断化され、各地の個体群が絶滅の危機にあるとされているが、その実態は明らかではない。これまでに、長江流域の二次林からなる低地 (< 200 m) および秦嶺山脈の高地 (1,000–2,000 m) に生息し、長江流域ではカンアオイ属の一種 *Asarum forbesii* を、秦嶺山脈ではウスバサイシン *A. sieboldii* を寄主として利用することが知られていた。

著者らは、2009年湖南省烏雲界国立自然保護区において、本種が生息することを発見した。この自然保護区は現時点で確認されている湖南省における一つの生息地と思われるが、生息状況の詳細は明らかではなかった。そこで、同保護区における本種の保全を目的として、その生息状況に関する予備的な調査を実施した。

調査の結果、本種は住民が火入れや採草などを行っている草地化した山頂付近だけに生息することを確認した。一方、本来の生息地と考えられる山麓部では、保護区指定とともに樹木や竹類の伐採が禁じられて樹木が高木化したせい、寄主植物はあるものの本種の成虫や幼虫は確認できなかった。卵や幼虫は、山頂付近でウスバサイシンからのみ確認された。寄主や生息地の標高は、秦嶺山脈の個体群に類似していた。

烏雲界国立自然保護区では、保護区内に居住する住民に耕作、採草、火入れなどを認め、自然との共存を図っている。以上のことから、湖南省南部のシナギフチョウ個体群は、採草や火入れ等の人為的攪乱によって存続している可能性がある。今後は、保護区の山頂付近で採草や火入れを継続するとともに、山麓部で樹木の伐採や草刈りを実施し、食草のウスバサイシンとシナギフチョウが生育するための環境整備を行って、本種の生息状況のモニタリングを継続する必要がある。

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